Evolving Simulated Modular Robots

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We evolved virtual modular robots for locomotion using a direct and a generative encoding. An important benefit of modular robots in evolutionary robotics is the ability to quickly evaluate various morphologies and control systems in reality. Our use of a modular approach to construct robot morphologies is thus geared towards enabling us to construct robots in reality. However, our approach can also be used to solely construct virtual creatures. The advantage of our system is that due to accurate collision detection and our models being based on real world counterparts, the evolved behaviors can seem more realistic. Simulating virtual creatures usually takes up a lot of computational power and in this example we tried to reduce the computational power required through using an generative encoding based on an L-System, similar to what Hornby [1] implemented. Although there are other types of generative encodings L-Systems have, to our knowledge, not been frequently implemented in any modular robotic system. We compared both the direct encoding and the generative encoding for its performance [2] and the video can be found at https://www.youtube.com/watch?v=HCDftic1AdA. In the generative encoding multiple modules have the exact same control parameters which was color coded as illustrated in fig. 1. Through the reuse of genetic material we think that a generative encoding makes useful abstractions of both morphology and control which may be valuable for creating physical robots.

References

[1] G. Hornby and J. Pollack, "The advantages of generative grammatical encodings for physical design," *Proceedings of the 2001 Congress on Evolutionary Computation (IEEE Cat. No.01TH8546)*, vol. 1, pp. 600–607, 2001.

[2] F. Veenstra, A. Faina, S. Risi, and K. Stoy, "Evolution and Morphogenesis of Simulated Modular Robots: A Comparison Between a Direct and Generative Encoding," in *Applications of Evolutionary Computation: 20th European Conference, EvoApplications 2017* (G. Squillero and K. Sim, eds.), (Amsterdam), pp. 870–885, Springer International Publishing, 2017.

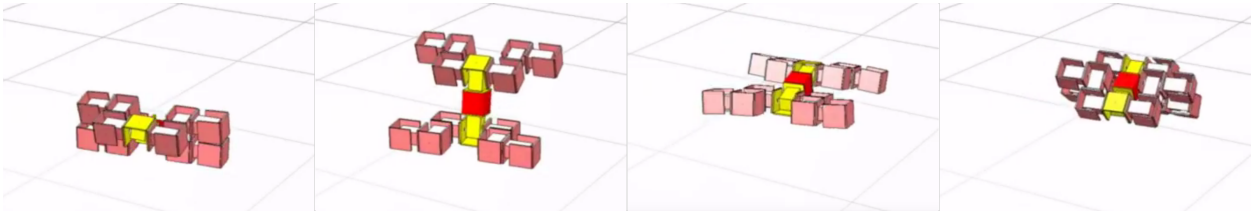

Figure 1: The figure above shows a robot evolved using the L-System. The different colors of the modules represent the genotypic traits being expressed. In this case, the robot consists of one base module (red) in the middle that is not actuated, yellow modules that are actuated by specific genotypic traits and gray modules that are not actuated